

**Geopositional Accuracy Validation of Orthorectified Landsat TM Imagery:  
Southeast Asia**

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## **Scope of Work**

This report provides results of an independent assessment of the geopositional accuracy of the Earth Satellite (EarthSat) Corporation's GeoCover™ orthorectified Landsat Thematic Mapper (TM) imagery over Southeast Asia. This imagery was purchased through NASA's Earth Science Enterprise (ESE) Scientific Data Purchase (SDP) program.

## **Background**

The EarthSat data procured through the SDP was orthorectified using a small set of scenes within a large geographic region, or block. Each of these scenes contained government provided ground control coordinates. A geometric model of the block was created based on the controlled scenes. This model was then applied to the rest of the scenes in the block.

## **Approach**

The orthorectified Landsat TM imagery's geopositional accuracy was estimated using a standard procedure that utilizes geodetic control points provided by the U.S. government. The approach was to use a small sample of independently controlled scenes to estimate the horizontal geopositional accuracy of the orthorectified products and to compare that estimate to the geopositional accuracy specified by NASA contract NAS13-98046 with the Earth Satellite Corporation. The contract specifies that the orthorectified TM product shall have a geopositional Root Mean Square Error (RMSE) accuracy of 50 meters.

## **Dataset**

Ten Landsat TM scenes over the Southeast Asia region were used in this activity. The selection of scenes used for the validation was dependent upon the availability of geodetic ground control points. Appendix A contains a map showing the location of the scenes used for validation in relation to the entire block processed by Earth Satellite Corporation. Earth Science Applications (ESA) Directorate personnel imported each orthorectified TM scene from GeoTIFF format to ERDAS IMAGINE format. Analysts used ERDAS IMAGINE software to analyze each 7-band scene.

## **Geodetic Control Reference Data**

The U.S. government provided a set of geodetic control points for use in this assessment. This ground control information was available only for specific parts of the globe. Of the available points, selected points were omitted as described in the Procedure section below. The control information was available in the form of both hardcopy documentation and softcopy computer files that duplicated the hardcopy coordinate documentation. The softcopy version enabled the importing of control point reference data into image processing software with minimal opportunities for error.

Table 1 provides scene-specific information for the Landsat TM scenes used in this assessment, including TM path/row identifiers, acquisition dates, the total number of control points available, and the total number of control points used in the validation activity for each scene. (*Note: These test points were used only in this validation and not in Earth Satellite Corporation's orthorectification process.*)

Table 1. Geodetic Control Point Information

<b>Scene Path/Row</b>	<b>Acquisition Date</b>	<b>Number of Control Points Available</b>	<b>Number of Control Points Used</b>
117/045	7/22/1990	8	7
119/042	6/3/1993	20	8
125/052	1/16/1989	13	11
127/048	11/6/1992	13	10
128/056	1/11/1991	12	6
130/050	12/21/1989	12	9
130/052	12/21/1989	12	9
131/046	2/9/1988	14	12
133/048	1/16/1989	12	9
134/045	1/23/1989	14	9
<b>Total</b>		130	90

### **Procedure**

The first step was to process the data using the Ground Control Point (GCP) Editor function available in the ERDAS IMAGINE image processing software. For each scene, the control Point ID, the X-Coordinate (UTM-East), and the Y-Coordinate (UTM-North) were entered into a comma-delimited ASCII file and then imported into the GCP Editor's Point ID, X-Reference, and Y-Reference fields. This action caused ground control point markers to appear on the image displayed in the reference viewer. The resulting image served as a reference dataset for checking geopositional accuracy and for determining approximately where each control point fell within an image. The analyst then used a separate ERDAS IMAGINE viewer to zoom in and to locate the feature associated with a control point on the given Landsat TM scene using a control diagram and descriptive remarks to place the test points in the proper location. This action populated the X-Input and Y-Input fields in the software's GCP editor. If the analyst could not discern the proper location or if the point fell outside the imagery's geographical extent, the point was omitted. The remaining points served as the input.

After selecting the usable control points, the analyst exported an ASCII file that contained the Point IDs, the input coordinates, and the reference coordinates for each scene examined. Because most of the ASCII files contained fewer than 20 test points, and because the Federal Geographic Data Committee recommends a sample size of at least 20 points, the files for individual scenes were combined into one large file. This file provided the input required to execute a Visual Basic program that computes X-differences and Y-differences and that estimates geopositional accuracy. For each point, the Visual Basic program computed the X-differences and Y-differences, the squares of the X-differences and Y-differences, the X-RMSE and Y-RMSE, and the net RMSE (accuracy) using the following accuracy formulas:

$$\begin{aligned} \text{RMSE}_x &= \sqrt{\frac{\sum(X_{\text{input}} - X_{\text{control}})^2}{n}} \\ \text{RMSE}_y &= \sqrt{\frac{\sum(Y_{\text{input}} - Y_{\text{control}})^2}{n}} \\ \text{RMSE}_{\text{net}} &= \sqrt{(RMSE_x)^2 + (RMSE_y)^2} \end{aligned}$$

where  $X_{\text{input}}$ ,  $Y_{\text{input}}$  are the coordinates of the input points;  $X_{\text{control}}$ ,  $Y_{\text{control}}$  are the coordinates of the reference points; and  $n$  is the total number of usable control points.

## **Results**

The calculations shown in Appendix B indicate that the RMSE, or net horizontal displacement, of the Southeast Asia GeoCover™ orthorectified TM imagery block is 35.97 meters.

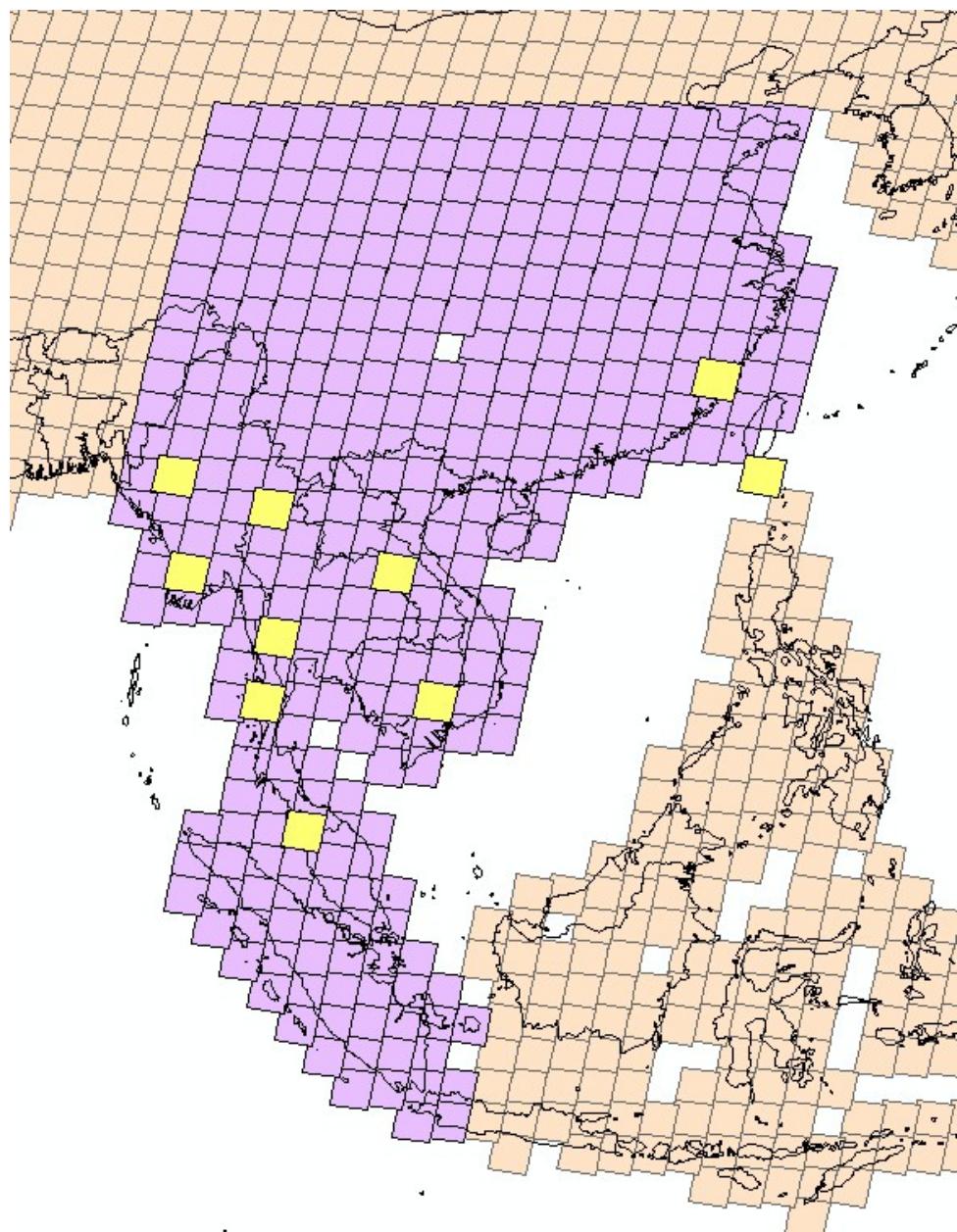
Appendix C provides a cartographic representation showing the locations of the scenes used in validating the Southeast Asia GeoCover orthorectified TM imagery block. This cartographic output, derived from a government-provided, vector-based program, shows overall error within each scene used in the validation via a resultant vector. The resultant vector's length represents the overall magnitude of error. The direction of the resultant vector is the overall direction of error.

## **Limitations**

Sample size and selection of test points were dependent upon the quantity, quality, and utility of the data available. These test points were selected from surplus ground control information that is available only for certain parts of the globe.

The possibility exists for inherent analyst bias because of the variability in image interpretation and pattern recognition capabilities. Final selection of points reflected user subjectivity.

**Appendix A**



Southeast Asia TM Coverage  
Validated scenes appear highlighted in yellow.

**Appendix B****Accuracy Computations for Southeast Asia Block GeoCover™  
(all measurements in meters)**

Number	X (geocover)	X (Control)	diff in X	squared diff in X	Y (geocover)	Y (control)	diff in Y	squared diff in Y
11704502	263166.42	263154.85	-11.57	133.87	2473180.63	2473161.90	-18.74	351.02
11704504	283091.27	283099.37	8.11	65.75	2471876.28	2471875.74	-0.54	0.29
11704505	262640.28	262647.99	7.71	59.40	2452296.64	2452274.51	-22.13	489.79
11704507	282680.67	282701.95	21.28	452.87	2456217.16	2456207.13	-10.03	100.66
11704508	264107.65	264116.82	9.16	83.95	2442633.08	2442631.70	-1.37	1.89
11704509	266277.74	266244.49	-33.25	1105.55	2432664.84	2432642.03	-22.81	520.49
11704511	272562.03	272572.77	10.74	115.25	2428893.33	2428880.47	-12.87	165.61
11804206	756159.03	756153.80	-5.23	27.38	2933306.69	2933325.29	18.60	345.79
11804209	751700.00	751671.16	-28.84	831.88	2909899.66	2909920.15	20.48	419.43
11804211	746848.78	746818.88	-29.90	894.25	2886838.34	2886869.88	31.54	994.65
11804213	747738.78	747720.79	-18.00	323.83	2871251.64	2871279.40	27.76	770.48
11804214	763618.70	763593.91	-24.79	614.57	2868607.47	2868630.84	23.36	545.81
11804215	740494.95	740477.83	-17.12	293.12	2851019.42	2851009.84	-9.57	91.63
11804217	736255.04	736280.40	25.37	643.49	2832597.64	2832605.65	8.01	64.14
11804219	732650.58	732633.32	-17.26	297.74	2817130.19	2817137.79	7.60	57.74
12605201	564695.72	564660.68	-35.04	1227.78	1342355.57	1342358.89	3.33	11.08
12605205	548016.89	547996.21	-20.68	427.86	1242804.75	1242807.39	2.64	6.96
12605203	560195.79	560167.57	-28.22	796.64	1292194.06	1292219.59	25.54	652.20
12605108	573017.89	572999.91	-17.98	323.45	1366572.36	1366555.49	-16.86	284.31
12505108	662203.73	662170.79	-32.93	1084.69	1352928.78	1352920.53	-8.25	68.05
12505201	727017.39	726935.79	-81.61	6659.49	1347521.79	1347536.09	14.30	204.52
12505202	719018.79	719002.70	-16.09	258.86	1291316.27	1291311.34	-4.92	24.25
12505204	614825.66	614819.64	-6.02	36.24	1261945.71	1261950.21	4.49	20.20
12505205	708911.76	708896.02	-15.74	247.77	1242173.21	1242169.28	-3.93	15.46
12505206	554273.83	554244.24	-29.60	875.92	1210294.36	1210265.20	-29.16	850.37
12505207	607217.74	607187.29	-30.44	926.73	1208426.03	1208440.53	14.51	210.45
12704801	392718.86	392713.64	-5.23	27.32	1990758.98	1990794.31	35.32	1247.77
12704802	463537.35	463515.39	-21.96	482.02	1991948.50	1991913.88	-34.62	1198.86
12704803	501643.98	501622.23	-21.75	473.20	1984811.33	1984819.22	7.88	62.17
12704804	393773.53	393762.29	-11.25	126.48	1960091.08	1960128.39	37.31	1392.29
12704805	460190.62	460185.97	-4.65	21.59	1957124.03	1957135.13	11.09	123.10

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12704806	499426.13	499397.15	-28.98	839.55	1957550.85	1957592.40	41.55	1726.00
12704807	353508.82	353474.38	-34.44	1186.28	1876775.47	1876735.60	-39.87	1589.44
12704808	445497.46	445517.96	20.49	419.87	1871877.18	1871884.43	7.25	52.51
12704809	499576.96	499568.75	-8.21	67.48	1883369.36	1883366.60	-2.76	7.61
12704810	342598.08	342613.58	15.49	239.97	1849017.83	1849031.28	13.45	181.01
12805510	749837.79	749829.85	-7.94	63.07	706517.49	706505.32	-12.18	148.23
12805602	580165.47	580122.83	-42.64	1818.10	682932.93	682934.25	1.32	1.75
12805603	642574.54	642609.07	34.54	1192.71	634902.45	634944.53	42.07	1770.22
12805605	737078.51	737113.77	35.26	1243.27	631415.30	631384.27	-31.03	962.94
12805606	630388.32	630409.78	21.46	460.70	577685.36	577654.44	-30.92	955.96
12805608	685489.91	685505.68	15.77	248.57	552325.01	552312.87	-12.14	147.35
13004981	455106.63	455109.10	2.47	6.11	1688353.32	1688368.37	15.04	226.26
13004985	562924.41	562974.24	49.84	2483.86	1667921.95	1667945.21	23.26	541.17
13104909	451554.91	451552.57	-2.35	5.51	1657842.52	1657827.40	-15.13	228.80
12905085	598660.38	598653.00	-7.38	54.51	1604547.87	1604550.43	2.56	6.58
12905089	590292.98	590325.53	32.54	1058.93	1524718.24	1524710.18	-8.06	64.95
13005001	520731.44	520701.20	-30.25	914.91	1618114.90	1618137.82	22.92	525.34
13005002	441903.93	441912.31	8.38	70.20	1580018.77	1580000.72	-18.06	326.02
13005003	545087.59	545089.62	2.03	4.10	1563890.08	1563861.32	-28.76	827.15
13005004	420690.44	420678.80	-11.64	135.56	1526278.18	1526243.79	-34.39	1182.56
13005108	465150.81	465187.50	36.69	1346.25	1355149.59	1355129.18	-20.41	416.53
13005109	542692.11	542693.27	1.16	1.35	1346830.43	1346856.35	25.92	671.78
13005201	382538.06	382482.21	-55.85	3118.81	1327275.83	1327277.55	1.72	2.97
13005202	456884.19	456872.64	-11.55	133.45	1303190.60	1303159.21	-31.38	984.87
13005203	534263.00	534252.99	-10.01	100.29	1300068.44	1300058.55	-9.89	97.75
13005204	382860.62	382838.27	-22.35	499.56	1247631.61	1247653.60	21.99	483.35
13005205	450441.99	450435.37	-6.62	43.87	1244880.16	1244832.39	-47.76	2281.28
13005207	379882.19	379850.43	-31.75	1008.38	1203496.18	1203465.84	-30.34	920.48
13005208	450847.78	450848.36	0.58	0.33	1192470.63	1192444.77	-25.86	668.71
13104601	433232.63	433219.20	-13.43	180.38	2317048.82	2317064.35	15.53	241.21
13104602	488491.01	488522.14	31.13	969.38	2318575.37	2318579.52	4.14	17.17
13104603	529115.68	529150.21	34.52	1191.68	2306330.45	2306379.90	49.45	2445.75
13104604	597666.31	597640.90	-25.40	645.27	2304317.89	2304325.28	7.38	54.48
13104605	412810.72	412803.47	-7.26	52.68	2245489.53	2245504.74	15.21	231.26
13104607	536002.31	535991.18	-11.13	123.93	2214113.66	2214127.41	13.75	189.00
13104608	581941.94	581927.59	-14.35	205.84	2206584.81	2206637.61	52.80	2787.84
13104609	405633.98	405608.34	-25.65	657.67	2174738.94	2174728.12	-10.83	117.19
13104610	462401.99	462388.90	-13.09	171.32	2161426.69	2161401.95	-24.74	612.27
13104611	522224.54	522188.23	-36.31	1318.39	2150387.80	2150353.02	-34.77	1209.24
13104612	566491.01	566478.34	-12.67	160.49	2145569.31	2145582.65	13.33	177.81

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13204606	433141.66	433131.38	-10.28	105.64	2247971.94	2247958.56	-13.39	179.23
13304801	667472.71	667456.80	-15.92	253.33	2012916.83	2012965.36	48.53	2355.50
13304802	738498.12	738481.00	-17.12	293.18	1991614.48	1991665.34	50.86	2586.80
13304803	834849.32	834814.82	-34.50	1190.59	1982033.86	1982168.07	134.22	18014.10
13304804	667700.34	667679.44	-20.90	436.81	1951631.26	1951650.14	18.88	356.44
13304805	758361.58	758331.32	-30.26	915.75	1938173.20	1938179.21	6.01	36.15
13304807	655226.20	655229.66	3.45	11.93	1900059.46	1900064.37	4.90	24.03
13304808	747047.06	747033.47	-13.59	184.65	1881960.63	1881980.79	20.16	406.37
13304810	645716.31	645685.93	-30.37	922.40	1850177.46	1850159.20	-18.26	333.49
13304811	731059.67	731034.32	-25.36	642.88	1833429.89	1833404.79	-25.10	630.16
13304504	747965.07	747956.08	-9.00	80.92	2425533.39	2425547.50	14.11	198.96
13304510	728512.37	728495.88	-16.49	272.05	2323951.07	2323954.93	3.86	14.88
13404504	606998.37	607005.24	6.87	47.14	2432134.64	2432125.00	-9.65	93.03
13404505	684892.42	684889.51	-2.92	8.50	2426816.43	2426824.29	7.85	61.68
13404507	594458.46	594424.85	-33.61	1129.81	2361429.33	2361416.28	-13.05	170.31
13404508	667016.56	666990.62	-25.94	672.94	2360561.72	2360557.93	-3.79	14.37
13404509	756797.23	756778.42	-18.81	353.85	2347400.24	2347407.12	6.87	47.25
13404510	585494.93	585492.95	-1.98	3.92	2323919.68	2323914.92	-4.76	22.67
13404511	677244.49	677284.09	39.60	1568.16	2319688.97	2319681.01	-7.96	63.38

Sum	53475.99
Average	594.18
RMSEx	24.38

Sum	62983.07
Average	699.81
RMSEy	26.45

RMSE Net      35.97      meters.

**Appendix C**

